MAICH_BioControl Strategies

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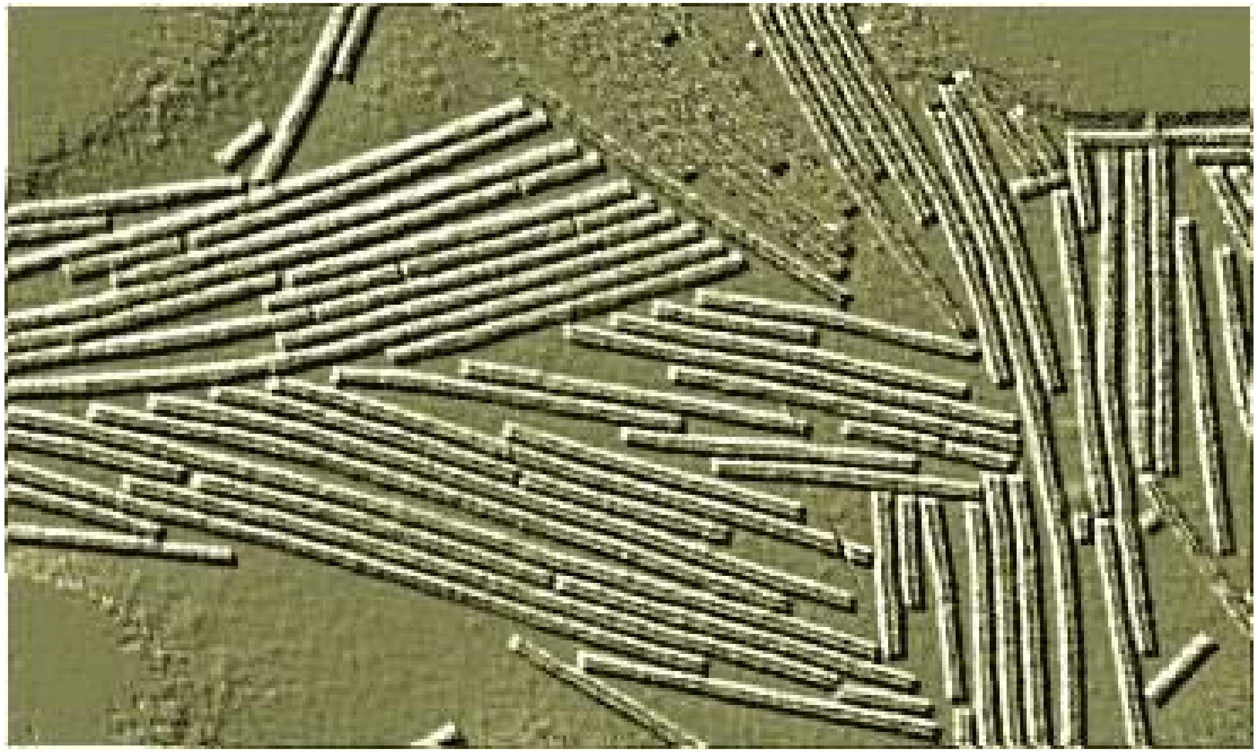
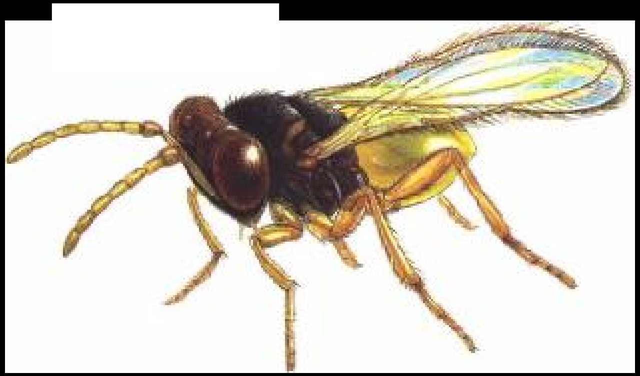
Biological Control Strategies

The ladybird *Rodolia cardinalis*, together with its prey, the cottony cushion scale
Foto: Henri Herrera

Why do you think pathogens are more common than parasitoids in augmentative control?



Steps for Augmentative Releases



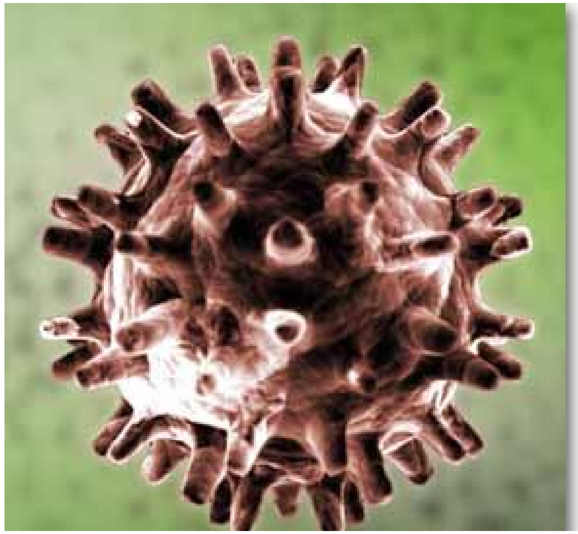
1. Identification of a market
2. Identification of right strain
3. Develop a method for mass production
4. Develop of storage methods
5. Develop of methods for transport
6. Develop release methods and dosages

Products Used in Augmentation

- Macroorganisms (insects and mites)



- Microorganisms (parasitoids pathogenes)

Macroorganism Mass Production

generally, to produce one natural enemy species for release you need to mass rear **at least two species**: The natural enemy and its hosts. Because this and the short shelf life of many natural enemies, macro-natural enemies for release usually cost more to produce than insecticides.

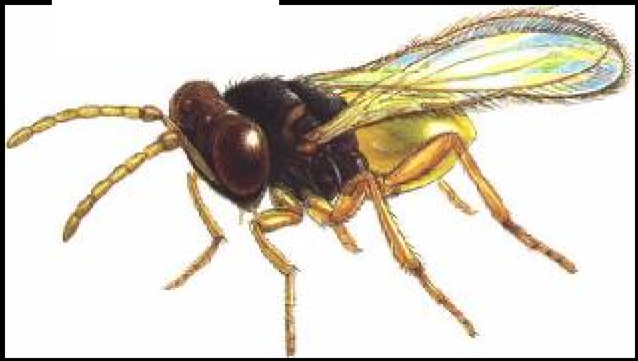
Insects Mass Production

In mass rearing <u>quality control</u> is extremely important. We need to make sure that no adaptation to rear conditions have occurred and that inbreeding depression is not a problem. **What is inbreeding depression?**

What is inbreeding depression?

- Inbreeding depression refers to the decrease of fitness in organisms that reproduce among relatives (or genetically related individuals).
- So when rearing insects for control one needs to make sure that they do not reproduce among relatives all the time.
- Introducing fresh field populations in the mass rearing effort is a way to prevent inbreeding depression.

Steps for Augmentative Releases



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Macroorganism Strain

- It is extremely important when we are dealing with microorganisms to Know the strain of the natural enemy
- These living organisms depend on abiotic and biotic conditions as much as their hosts. The slide shows an example of a fungal pathogen (*Verticillium chlamydosporium*) that attacks nematode eggs that live on galled tomato roots.
- Different strains of this fungal parasitoid differ in their ability to live in the root area. So picking the right strain is really important.

Microorganism Strain

- A strain that attacks the nematode eggs in the laboratory, **might perform extremely poor out there in the real world** if it is unable to live in the roots of the plants.
- In this particular case even the varieties of tomatoes involved (i.e. the host-plant variety), affected particular strains performance.
- Living organisms do not only interact with one but with many factors. The ecological niche is a multidimensional space.

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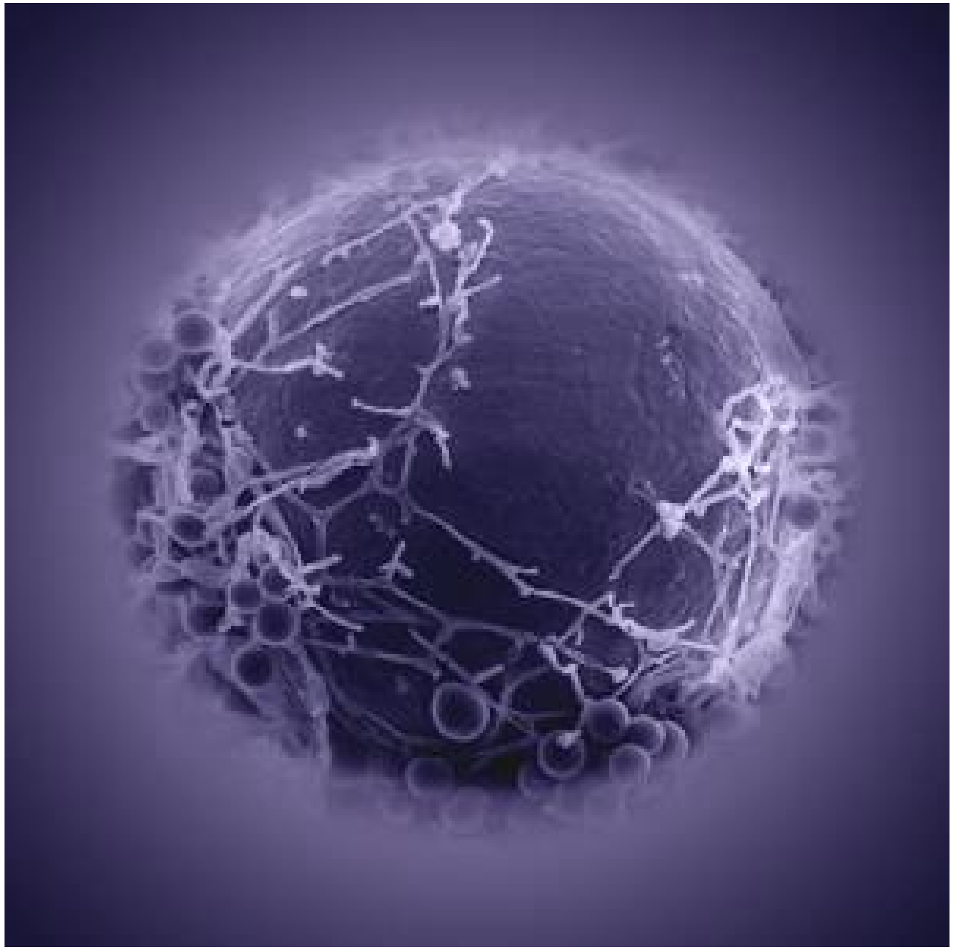
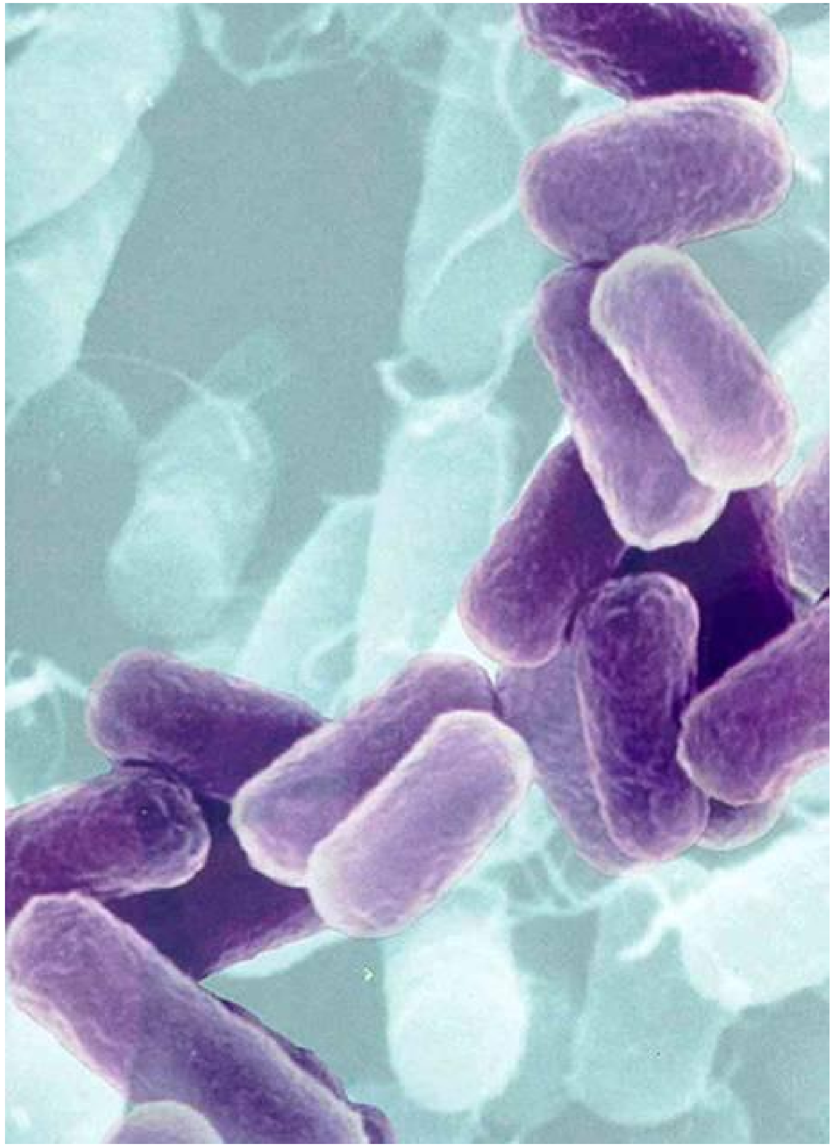
Microorganism Mass Production





Microorganism Mass Production

- Some microorganisms are very easy to mass-production (e.g. *Bacillus thuringiensis*). Others are a little bit more challenging to mass-production.

factors such as

1. the fermentation environment,
2. the right balance between nitrogen and carbon in the growing media and
3. the right amount and kind of nutrients

- sometimes need to be carefully chosen for the pathogen to grow properly and in large numbers.

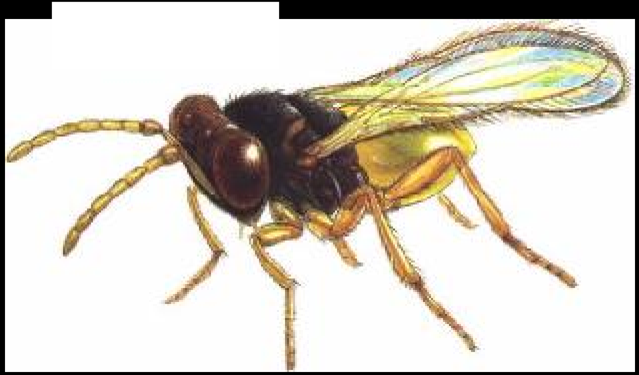
Microorganism Mass Production

- Although a lot of microorganisms can be produced without the need of live organisms some require live hosts.
- As with beneficial insects, quality control is important for microorganisms mass production operations.

Quality control issues in mass produced microorganisms involve

1. Assurance that cultures have not become contaminated. Especially by microorganisms pathogenic to humans
2. Assurance that virulence to target species has not declined
3. Assurance that active unit numbers (e.g. spores) are being produced as it is stated for the product

Steps for Augmentative Releases



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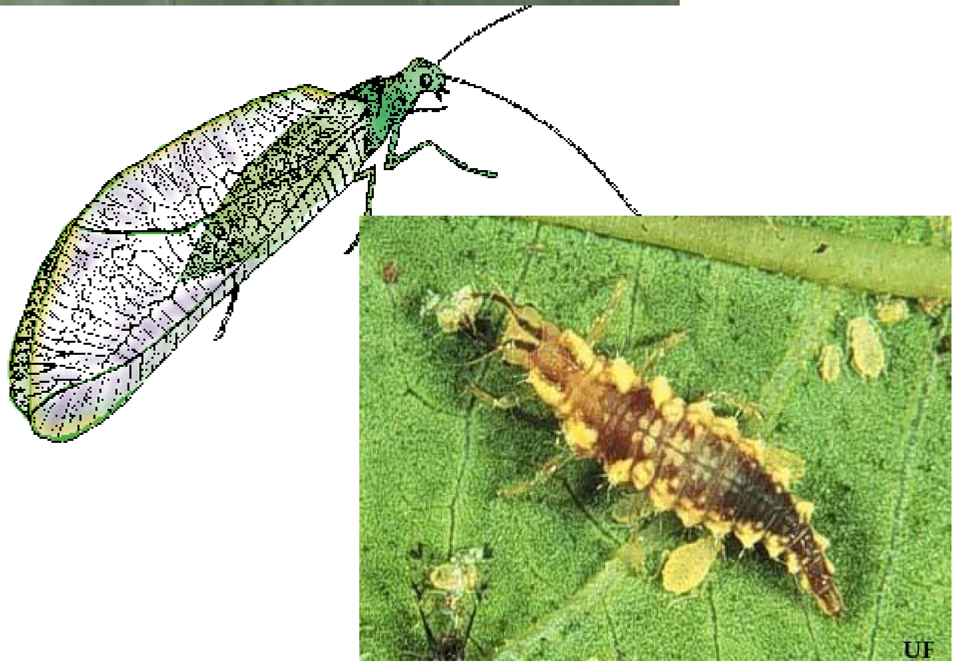
Macroorganism Storage and Transport



Microorganism Storage and Transport

1. It is not difficult to store microorganisms for a year.
2. Some might need to be refrigerated.
3. Some microorganisms are only able to be stored for up to a couple of months.
4. This storage problem is one of the major drawbacks of biopesticides.

Insects (Macroorganism)
Storage and Transport?

- One needs to make sure that insects do not die during rearing or transportation due to overheating or cannibalism.
- To prevent cannibalism some insects are packed with

1. buckwheat hulls,
2. paper, or
3. vermiculite

to provide hiding places or refuges.

Microorganism Storage and Transport

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Macro organism Releases

Factors influencing successful macro organism releases. shared a lot of common factors with successful insecticide applications:

1. Application rate, timing (including time of day)
2. synchrony with the pest's susceptible stage,
3. coverage,
4. severity of rainfall after application, and
5. number of applications

will all influence successful releases of macro organisms and successful insecticide application as well.

However, although several microorganisms can be released using the same kind of equipment used for insecticide applications,

Insects are released manually

Microorganisms Release

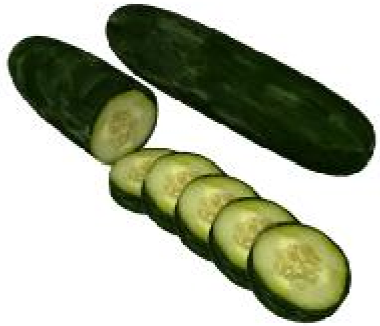
1. Same equipment used for insecticide applications can be used to release microorganisms.
2. Care should be taken in placing microorganisms close to the target since their ability to move is not as great as the one of macro organisms.
3. To protect certain microorganisms from abiotic factors they are usually sprayed in formulations that protects them until infection from dangers such as desiccation and UV light.
4. Microorganisms can also be aided by adding materials to the formulations that make infection easier.

Microorganisms Release

Microorganisms Release

1. Although mostly used in greenhouses augmentative bio control is also practiced in the field.
2. For certain species of pests augmentative control in the field works well.
3. *Thricogramma* spp parasitoids, for example, are released to control certain lepidopteran pests in field situations.
4. More research and improvements in regulation policies and marketing could make augmentative biocontrol a more widespread practice



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Bio-control Strategies

- Classical Biological Control
- Augmentation
  - Inundation
  - Inoculation

- Conservation Biological Control

conservation
biological control!

Conservation Biological Control

Habitat Management to Provide Conditions that Promote Biological Control

Based on:

- **Understanding Community Food Webs**
- **Manipulating Habitats to create Refuge**
- **Understanding how Landscapes act as "Filters" for large-scale and long-term movement of organisms**

Conservation Biological Control

- This method was developed to protect or conserve natural enemies that were being decimated by the use of insecticides.
- Only later it was realized that not only one could conserve but also enhance the presence of natural enemies.

Conservation Biological Control

question

How we can enhance the presence of natural enemies?

Answer

By planting flowers they use to feed from nectar for example

Conservation Bio-control Definition

" Modification of the environment or existing practices to protect and enhance specific natural enemies or other organisms to reduce the effect of pests"

Conservation Biological Control

- natural enemies are not released but their populations are enhanced by improving the conditions in the landscape for them.
- In other words, conservation biological control attempts to improve natural enemy niches to bring them the closest possible to the ideal conditions for the control agents.

Conservation Biological Control

- Natural enemies are not released
- Enhance control by indigenous agents
- Habitat management
  - Conservation (i.e.,habitat refuges)
  - Food sources

Conservation Biological Control

- For conservation biological control to work, the biology, ecology and behaviors (i.e. the autoecology or natural history) of pests and their natural enemies needs to be understood
- We need to understand which factors are affecting negatively natural enemy populations and eliminate those factors.

Conservation Biological Control

- Also, factors limiting natural enemy efficiency must be identified, understood and manipulate to enhance natural enemy populations or to favor encounters of natural enemies and pests.
- Thus, the more we know about the biology of individual natural enemy species the more successful we will be in trying to improve their niche so they can control pests better.


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Example: Beetle banks

- Beetle banks is one of the practical things that are customarily done as part of conservation bio-control strategies.
- Beetle banks consist of areas within crop fields in which native vegetation is allowed to establish over time.
- This native vegetation patch provides habitat for predatory arthropods (like carabid beetles and spiders) that disperse into the crop and control pests.
- Thus, even though they are called beetle banks they can hold more kinds of natural enemies than just predatory beetles.

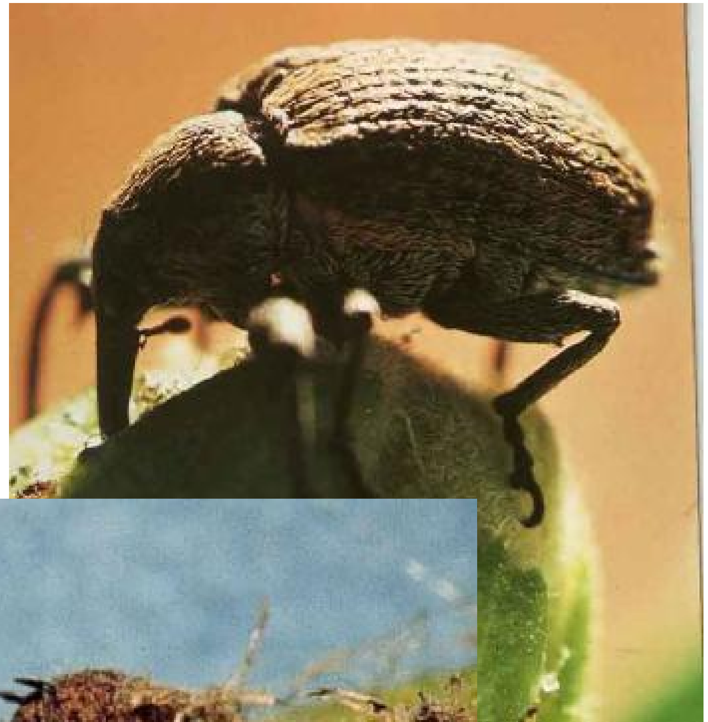
cropping system diversification,

Beans and lettuce

Taking advantage of epizootics

- Another strategy used in conservation biological control is to take advantage of epizootics (or animal epidemics).
- Example: The cotton aphid was never considered a pest in the US until insecticide application began to control the boll weevil in the 1940s. A fungal disease was observed to attack cotton aphids killing them in large numbers. This was observed in 1988 by Don Steinkraus.

Taking advantage of epizootics



Taking advantage of epizootics

- The fungus is an obligate pathogen of cotton aphids (i.e., it cannot be reared outside the cotton aphid) so mass production was not an option, because it was difficult to rear the right number of aphids needed for the fungus to be produced at industrial levels.
- However, the fungus spreads fast and is very infective and compatible to the weather conditions of the places that present cotton aphid infestations.

Avoiding insecticide use

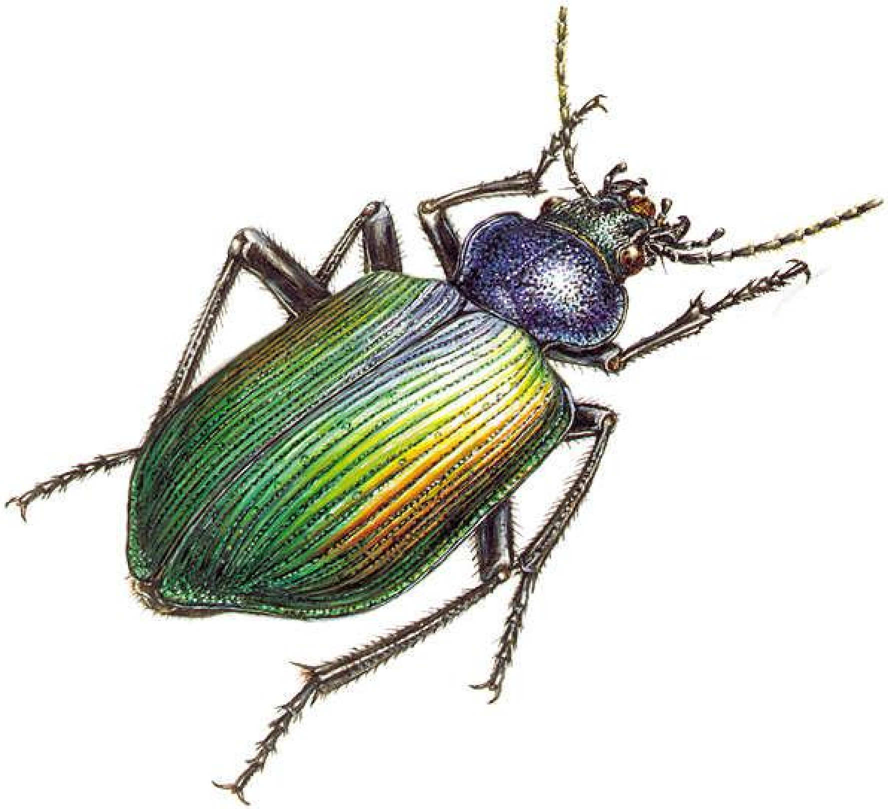
Avoiding insecticide use

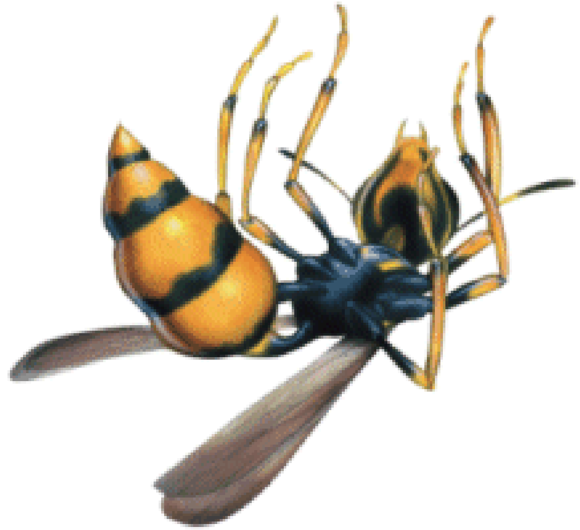
- Another way to practice conservation biological control is the avoidance of insecticide use. One can conserve natural enemies by reducing the impact of insecticides on their populations.
- The use of insecticides should be avoided as much as possible so natural enemy populations can increase to their maximum level.
- Insecticides might kill the natural enemies of the pests being controlled.

Avoiding insecticide use

- Also, insecticides might kill natural enemies of other herbivores in the system that were not pests before the insecticide applications but that become pests after insecticide use, creating what are called secondary pests.
- Insecticides reduce pest numbers to such low levels that persistence of natural enemies of those pests become impossible.
- Insecticides sometimes do not kill natural enemies but reduce their longevity or reproductive rate thereby affecting their efficiency.
- When an insecticide does not kill an organism but affects its fitness in anyway we refer to the insecticide causing sub-lethal effects.

Selective Pesticides





Selective Pesticides

- to use conservation bio-control in an IPM context, there is a need to use it in combination with insecticides.
- Regarding insecticide use, the good news is that not all natural enemy species are affected the same by different insecticides.
- Some species tolerate certain insecticides and other species have evolved resistance to insecticides.

Selective Pesticides

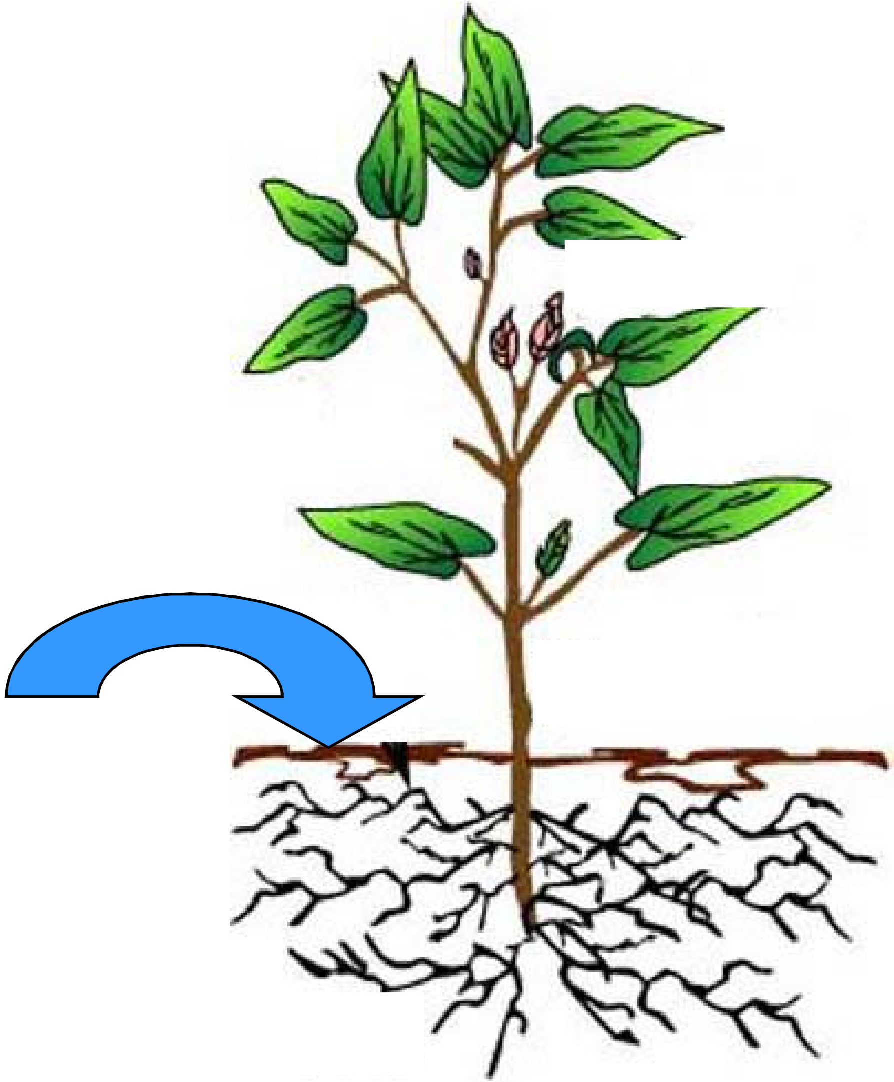
- If we know which natural enemies are unaffected by which kinds of insecticides, effective chemical control can sometimes be used with a reduced harmful effect on natural enemies.
- These kind of insecticides that harm the pest but do not harm selected natural enemies are called "selective pesticides".

Selectivity

1. physiological (selective pesticides)
2. Behavioral (avoid exposure)

   granular or systemic insecticides
3. Limit insecticide applications

Avoid exposure



Avoid exposure

granular or systemic insecticides in an IPM framework,

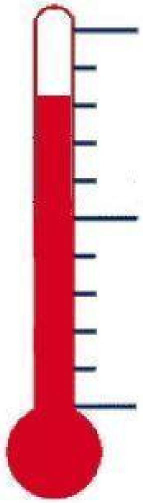
- Granular applications of insecticides in the soil will not affect natural enemies in the foliage.
- Similarly, systemic pesticides will affect only insects feeding on the plant.
- Insects not feeding on the plant will not be affected.
- Predators consuming insects that have fed on treated plants may be affected though.

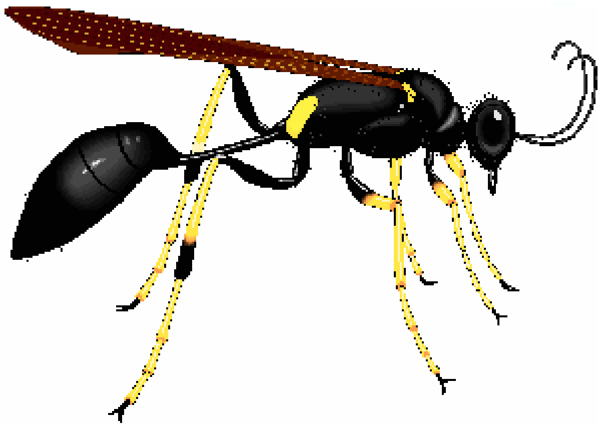
Limit insecticide applications

Limit insecticide applications

- If insecticides are going to be applied then limit their use. Limit insecticide applications to every other row.
- In this way, refuges or pesticide free zones are created within the field. These zones act as natural enemy sources.
- Insecticides can be schedule to be applied before the arrival of natural enemies or before they are present at a vulnerable state so they do not get killed as much.

Enhance natural enemy populations





Intercropping

Intercropping

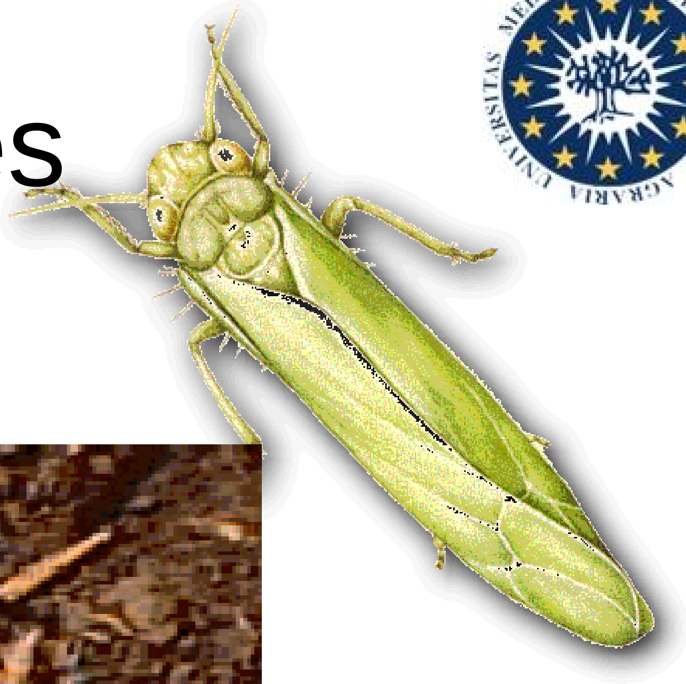
- Planting more than one crop in a field simultaneously. It is a form of polycutlure .
- This practice have shown to reduce pest numbers by increasing the number of natural enemies and their efficiency.
- The problem is that not all combination of crops work the same. More research is needed in this front.

Cover crops

Cover crops

- Cover crops provide resources and refuge to natural enemies. In Australia, for example, 80 to 90% of citrus orchards in the major citrus areas use cover crops to fight phytophagous mites. The cover crop they use is Rhodes grass (*Choris gayana*). **Intercropping**
- A grass provides pollen that acts as alternate food for predatory mites. Other farmers use hairy leave *Eucalyptus* trees to trap this pollen and build up natural enemy populations that feed on it.
- As with hedgerows, cover crops can attract pests and/or compete with the crop for water or other resources. (disadvadage)

Crop residues



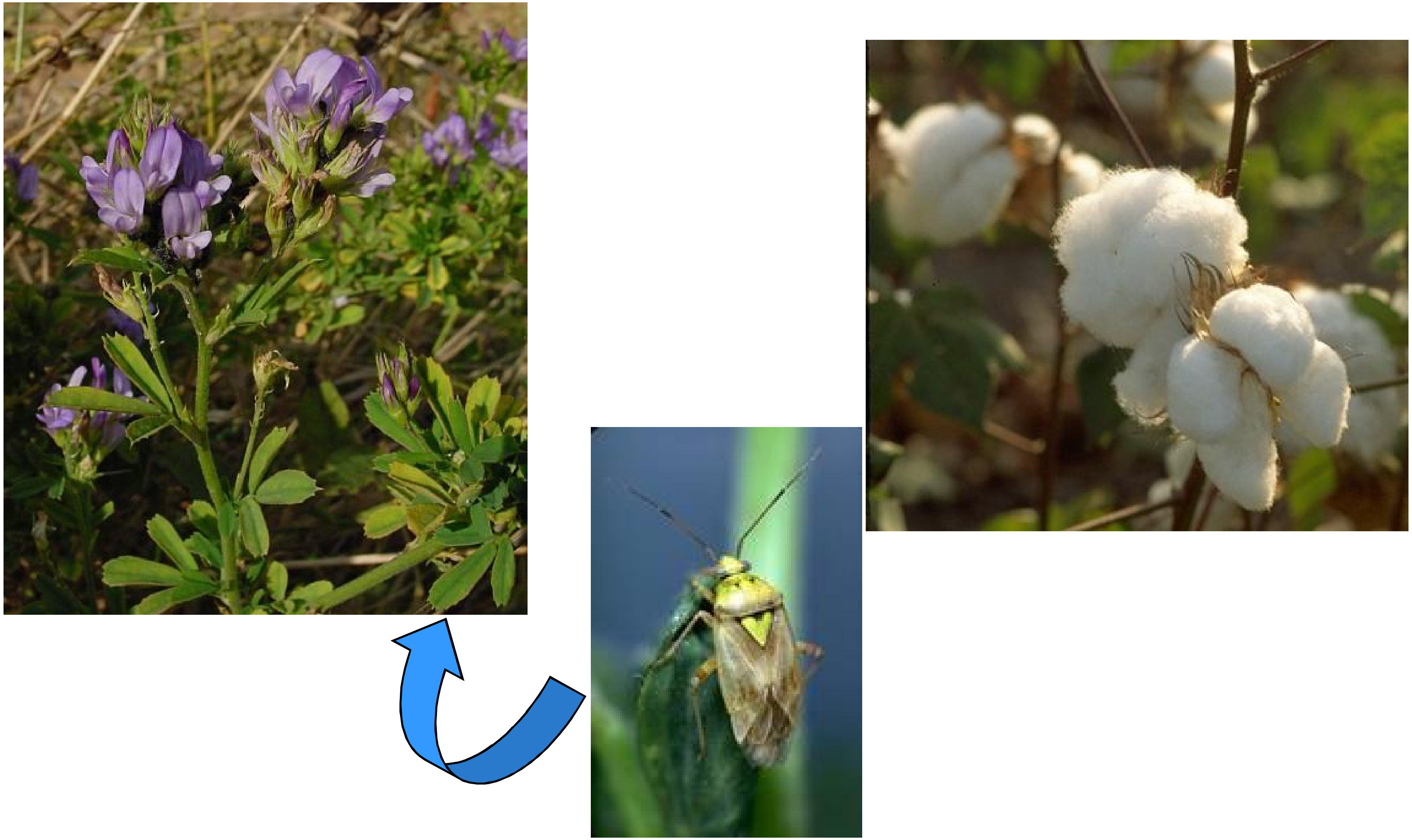
Crop residues

- In some agricultural systems, natural enemies persist in the field in crop residues.
- Burning or disposing these residues might negatively impact natural enemy populations associated with cropland.
- If the crop residues are not burned but instead spread back onto fields the sugarcane leaf hopper can be effectively controlled by the natural enemies that live in the residues.

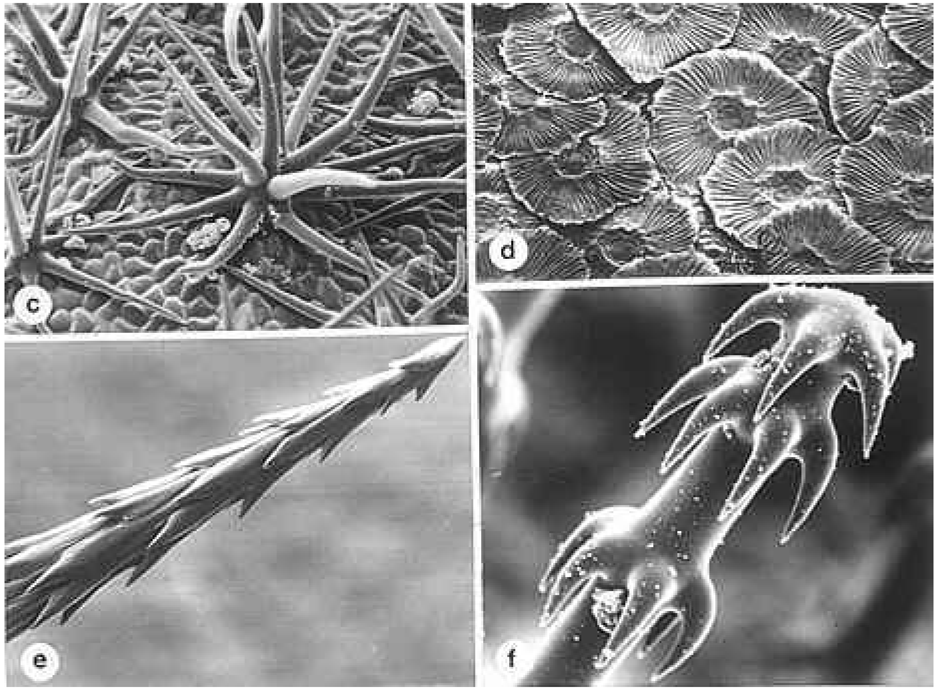
Crop management

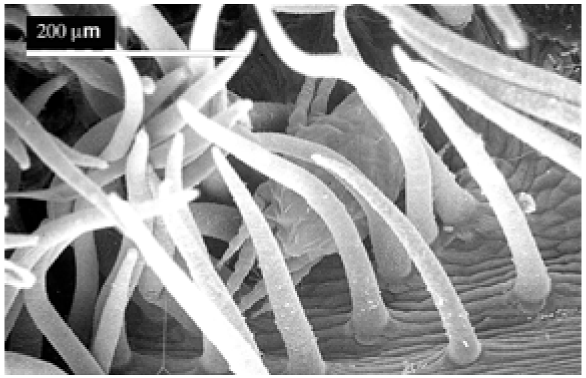
- The lygus bug, *Lygus hesperus*, prefers alfalfa over cotton. Thus, by planting alfalfa close to cotton, *Lygus* bugs can be kept in their preferred crop and be away from cotton.
- Also, alfalfa serves as a refuge and habitat to a vast array of natural enemies. The management problem comes when all the alfalfa is cut. Alfalfa is cut periodically. When this happens the *Lygus* migrates to cotton and may generate some problems there. Management practices that allow to cut part of the alfalfa field or to plant the alfalfa in some sort of inter-planting regime may help in keeping *Lygus* bugs on alfalfa. The problem with the inter-planting solution is that some plants may have different water regimes for example, and keeping them together might be a little complicated. Alfalfa and cotton, have in fact, very different water regimes, so if planting them together this factor needs to be taken into consideration for irrigation purposes.

Crop management



Plant characteristics





Plant characteristics

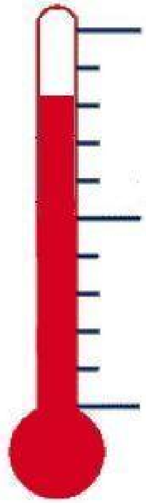
- Certain varieties of plant present hairs (trichomes) that make natural enemies' life a little difficult. This hairs come in many shapes.
- Sometimes hairs in leaves are good, such in the case of predatory mites that inhabit hairs on the veins on leaves called domatia.
- waxes in leaves might affect the performance of natural enemies. On waxy leaves parasitoids spend more time grooming and less time ovipositing.
- So picking the right variety of plant matters when trying to reduce pest populations.

Soil

Soil

- We need more research to understand the potential role of soil in controlling pests. Some soils have a suppressive effect of pests. Mainly due to the accumulation of pathogens that affect pest populations.
- Some soils can become suppressive over the years due to the accumulation of these natural enemies. Tillage practices in certain crops may mask the suppressive effects of soil by burring beneficial agents deep into the soil where they cannot infect pests.

Physical environment



Physical environment

- Water can be used to increase humidity and decrease temperatures to make habitats more favorable for natural enemies.
- As we have already seen beetle banks, hedgerows, and cover crops all provide adequate micro-habitat conditions for natural enemies.
- We might try to improve field conditions not only there but in the crop itself if possible by for example adding crop residues as discussed before or by adding more water to the crop.

Hedgerows and weed strips

Examples of conservation biological control in Oregon

Calendula, orache, *Alyssum*, insectary strips, among vegetable crop rows

Sunflower, buckwheat and wild Cruciferae insectary plantings

Hedgerows and weed strips

- Hedgerows and weed strips are much more effective if kept for long time (i.e. “permanently”) so natural enemy populations can build up.
- Example: Leafhoppers that attack grapes are controlled in California vineyards by the parasitic wasp *Anagrus epos*. The problem with *A. epos* is that it cannot overwinter in leafhoppers because they do overwinter as adults. However, this parasitoid can also overwinter in eggs of the prune leafhoppers. Thus, leafhopper populations in grapes can be lowered by planting prune trees in the vicinity so the parasitoid can overwinter and remain in the field

Adding food and shelter to crops

VERY IMPORTANT

Adding food and shelter to crops

- Food for natural enemies can be supplied directly to crops to bolster natural enemy populations.
- Mixtures of protein, water and sugar have been applied to cotton to control aphids by providing these resources to lacewings.
- Pollen could also be applied to enhance predatory mite populations. Shelters can also be artificially provided.
- Polyethylene bags, boxes, empty cans, straw bundles and leaf litter have all been added to crops to increase populations of natural enemies such as ants, spiders, earwigs and others.